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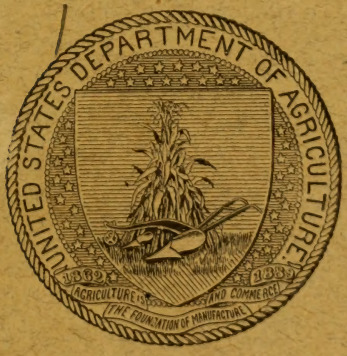
U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF ENTOMOLOGY—BULLETIN No. 56.
L. O. HOWARD, Entomologist.

THE BLACK HILLS BEETLE,

WITH

FURTHER NOTES ON ITS DISTRIBUTION, LIFE HISTORY, AND METHODS OF CONTROL.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST.
BY
A. D. HOPKINS, PH. D.,
In Charge of Forest Insect Investigations.



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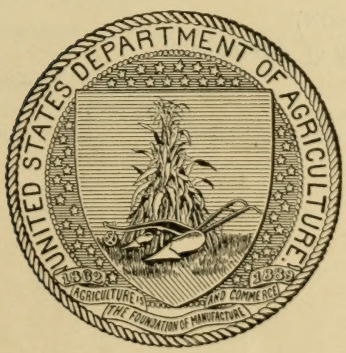

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1905.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., November 14, 1905.

Sir: I transmit herewith the manuscript of the report of Dr. A. D. Hopkins, of this Bureau, on an investigation of the Black Hills beetle, with especial reference to its occurrence in the Pikes Peak Forest Reserve and in the vicinity of Colorado Springs and Palmer Lake. This investigation was made at the request of the Bureau of Forestry, and I recommend the publication of the report, which brings the information concerning this species up to date, as Bulletin 56 of this Bureau. The figures and plates are necessary for the illustration of the text.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Introductory	5
Historical references	5
Report on forest insect investigation in the Pikes Peak Forest Reserve	8
Objects	8
Explorations	9
Summary of results, conclusions, and recommendations	9
The Black Hills beetle	10
Characters of the beetle	11
Characters of the gallery	11
Characters of the infested trees	13
Life history	15
Natural and artificial influences	16
Drought and cold	16
Lightning	16
Storms	16
Fire	16
Commercial cutting	17
Summer cutting in patches	17
Trap trees	17
Natural enemies	18
Insects	18
Birds	18
Diseases of insects	18
Secondary enemies of the trees, and neutral insects	18
Methods of control	19
Application of the method in the Black Hills	19
Application of the method in Colorado	20
Further recommendations relating to the control of the beetle	21
Note	22
Index	23

ILLUSTRATIONS.

PLATES.

Page.

PLATE I. Work of the Black Hills beetle. Fig. 1.—Primary galleries and larval mines in inner bark. Fig. 2.—Marks of primary galleries on surface of scoring chip 12

II. Work of the Black Hills beetle. Fig. 1.—Marks of primary galleries on surface of wood when bark is removed. Fig. 2.—Freshly attacked tree, showing pitch tubes; adjoining tree not attacked 14

TEXT FIGURES.

FIG. 1. The Black Hills beetle: adult 11

2. Work of the Black Hills beetle: primary galleries and larval mines in inner surface of living bark 12

3. Work of the Black Hills beetle, in inner bark of dead tree 13

4. Work of the Black Hills beetle: pitch tubes on surface of bark 14

5. The Black Hills beetle: larva 15

6. The Black Hills beetle: pupa 15

THE BLACK HILLS BEETLE.

(*Dendroctonus ponderosæ*[a] **Hopk.**)

INTRODUCTORY.

The object of this bulletin is to give additional information on the distribution, life history, habits, and methods for the control of the Black Hills beetle, based on further investigations by the writer and his field assistants, and information through correspondence with forest officials and others.

It is now known that this beetle occurs in the eastern sections of the Rocky Mountain region from the Black Hills of South Dakota to northern New Mexico; and there is evidence that its distribution extends westward into Utah and northern Arizona.

It attacks and kills the western yellow or bull pine (*Pinus ponderosa*) and the white spruce (*Picea canadensis*) in the Black Hills of South Dakota; and the western yellow or bull pine, the limber pine (*Pinus flexilis*), and the Engelmann spruce (*Picea engelmanni*) in the Pikes Peak region.

Wherever this insect is found in abnormal numbers its depredations on living timber are more or less extensive. It has killed between 700,000,000 and 1,000,000,000 feet of timber in the Black Hills Forest Reserve, and is also demonstrating its destructive powers in central Colorado and New Mexico.

The method for its control recommended by the writer and adopted in the Black Hills and Pikes Peak region has been sufficiently tested to show that it is both practicable and effective, and that, under proper management, a forest can be protected at a moderate expenditure, or almost without cost where there is a market for the timber.

HISTORICAL REFERENCES.

Probably the earliest published information on the destructive work of this insect is that by Prof. H. S. Graves,[b] in which he refers to the dying pine timber in the Black Hills of South Dakota. He stated that the patches of dying and dead timber are usually rectangular in shape, following the tops of the divide or ridges and running lengthwise up and down the slope, and that this injury was probably caused by bark-boring insects of a species of Scolytidæ.

[a] Family Scolytidæ.

[b] Ninth Rept. U. S. Geol. Surv., Pt. V, p. 87, 1897–98.

Specimens of the bark-boring insects found attacking the living trees in the area mentioned by Professor Graves were sent to the Department of Agriculture in August, 1898, by Mr. William M. Pratt, from Piedmont, S. Dak., and by Mr. H. E. Dewey, from Lead, S. Dak., and more specimens were sent in by Mr. Dewey in August, 1899. These were at first identified as *Dendroctonus rufipennis* Kirby, and as *D. terebrans* Oliv.; but in 1900 they were examined by the writer and were found to represent an undescribed species of Dendroctonus. Specimens of the same insect were also found in the collections of the American Entomological Society, at Philadelphia, and in the United States National Museum, labeled South Dakota, Utah, and Colorado, the latter from Pikes Peak, July 10, 1900.

In September, 1901, upon the request of Mr. Gifford Pinchot, Chief of the Bureau of Forestry, and under the direction of Dr. L. O. Howard, Chief of the Division of Entomology, an investigation of the trouble affecting the timber in the Black Hills Forest Reserve was made by the writer; and on October 23, 1901, a typewritten report was submitted to Doctor Howard and Mr. Pinchot which, with additional data and illustrations, was transmitted for publication in January, 1902, and was issued in that year as Bulletin No. 32, new series, of the Division of Entomology. In this bulletin the new species found to be the primary cause of the death of the timber was described under the name of *Dendroctonus ponderosæ*, and certain facts in its habits and life history were presented, together with *recommendations based thereon, for felling and barking the infested trees at a time of the year when the mere removal of the bark from the main trunk, without burning, would be sufficient to kill the broods.*

In July, 1902, Mr. John P. Brown, secretary of the International Society of Arboriculture, issued a "Special Rocky Mountain Bulletin on the Destructive Beetles of *Pinus ponderosa*," in which reference is made to the destruction of pine timber in the Black Hills of South Dakota and in Colorado by two beetles, which he designates as the "large destructive barkbeetle" and the "small destructive barkbeetle," but he omitted their scientific or technical names. Therefore it is not known to what particular species he referred, or whether or not he had two or more species confused. It is evident, however, that the depredations in the Black Hills were caused by *D. ponderosæ*, previously described.

Mr. Brown recommended the remedy of felling and barking the trees and burning the bark with the tops; but his main argument was for the protection of insectivorous birds.

In 1902 Mr. J. L. Webb, special field agent in forest insect investigations, assigned from the Bureau of Forestry, and working under instructions from the writer, spent five months (May 28–October 30)

in the Black Hills Reserve, studying the life history and habits of the beetle. He also conducted extensive trap-tree experiments, in which over two hundred matured healthy trees were girdled or felled to determine their attractive influence on the Black Hills beetle and other forest-tree insects. In August, 1902, and June, 1903, the writer visited the reserve and made special studies of the beetle and of the trap-tree experiments. In October and November, 1902, and November, 1904, Field Assistant H. E. Burke visited the reserve for the same purpose, and Forest Ranger W. G. Courtney made records of observations on the trap trees from June to October, 1903.

August 12, 1902, Prof. C. P. Gillette sent specimens of a barkbeetle from Bailey, Colo., with a statement that he had found it in dying pine trees. This proved to be the Black Hills beetle, *D. ponderosæ*, and was the first authentic record of its work in Colorado.

During a special investigation in May, 1903, the writer found the same species in northwestern New Mexico, in the vicinity of Vermejo, where it was attacking and killing the matured pine timber over a large area. Here the method of cutting and barking the infested trees was recommended.

In December, 1904, specimens of the beetle were sent by Mr. P. P. Blass, with a statement that a large amount of timber was dying in the vicinity of Palmer Lake. In reply, Mr. Blass's attention was called to the dangerous character of this enemy of pine trees, and published data on the subject, supplemented by written instructions for the cutting and barking of infested trees, were sent him. Upon the suggestion of Mr. Blass, on February 15, 1905, a set of bulletins and written instructions were also sent to the town board of Palmer Lake. This resulted in the cutting and barking of a large number of infested trees by different people in that vicinity. Upon information from the clerk of the town board of Palmer Lake that the timber was dying in the forest reserve, adjoining the town property, information was conveyed by the writer to the Forest Service, together with copies of recommendations for the cutting and barking of infested timber; also stating that upon receipt of information from the supervisor as to the character and extent of the trouble in the reserve, the Bureau of Entomology would take the matter up with them and, if necessary, send a man into the field to make special investigations. Later a report of May 11, 1905, addressed to the Forest Service by Supervisor Clarke, was referred to the writer on May 17. In reply to this, more detailed instructions were sent to Supervisor Clarke, for the identification of the trees which should be cut, with the statement that it would be more desirable for the Bureau to make an investigation in the fall.

In a letter dated July 14, 1905, Prof. C. P. Gillette, State entomologist of Colorado, stated that during a visit to Palmer Lake he

noted that a large amount of timber was dying in that vicinity. The specimens sent to the Bureau of Entomology with his letter proved to be the Black Hills species, thus leaving no doubt regarding the primary enemy and the great danger of an invasion which might soon extend beyond control unless active measures were adopted.

In the meantime, General Palmer, certain members of the faculty of the Colorado College, and others interested in the protection of the forests in the vicinity of Colorado Springs had inaugurated an active campaign to control the ravages of the beetle, in which the services of Prof. Lawrence Bruner, of the University of Nebraska, were secured to make investigations and give instructions in felling and barking the timber. Two reports were submitted by Professor Bruner to General Palmer, one dated August 2, the other September 19. These reports, together with correspondence and other data, were published in Arboriculture for October, 1905, pages 205–212.

Under Professor Bruner's direction between 600 and 800 trees on private lands in the vicinity of Glen Eyrie, Colorado Springs, and adjoining the reserve were felled during August, September, and October, and the bark removed and burned with the tops, to kill the insects with which they were infested.

On September 16 a full report of the results of explorations by the forest rangers in the Pikes Peak Forest Reserve was submitted to the Chief of the Forest Service by Supervisor Clarke. This included specified descriptions of ranges and sections containing infested timber which General Palmer had requested permission to cut and bark at his own expense, for the further protection of the surrounding public and private forests. Copies of these typewritten reports and statements were submitted by the Acting Forester for consideration, and upon consultation with Mr. Gifford Pinchot, Forester, and Mr. Overton W. Price, Associate Forester, it was decided that the writer should proceed at once to make the necessary investigation on which to base recommendations for the consideration of forest officials and others, in further efforts to control the destructive insects in and around the Pikes Peak Reserve.

This investigation was made October 5 to 13, 1905, and the following report submitted:

REPORT ON FOREST INSECT INVESTIGATIONS IN THE PIKES PEAK FOREST RESERVE.

OBJECTS.

The object of this special trip was to investigate the character and extent of depredations by the pine-destroying beetle of the Black Hills (*Dendroctonus ponderosæ* Hopk.) in the pine forests of the Pikes Peak Forest Reserve, in the vicinity of Colorado Springs and Palmer

Lake and at such other points as might be deemed necessary; to give instructions to the forest officials and others in carrying out our recommendations for the control of this and other insects directly associated with the dying timber, and to determine for the Forest Service the approximate extent of necessary cutting of timber on the reserve to protect the remaining living timber in the vicinity of Colorado Springs and adjoining private estates, as proposed by Gen. William J. Palmer.

EXPLORATIONS.

Beginning on the morning of October 5 explorations were made as follows: Glen Eyrie trail on mountain northward, returning via Douglass Canyon; October 6, from Glen Eyrie by way of Colorado City, Bear Creek Canyon, High Line road, to Bruin Inn, returning by way of North Cheyenne Canyon, Colorado Springs, and Palmer Park; October 7, from Glen Eyrie by way of Manitou, over Crystal Park trail to Crystal Park, returning by the Bear Creek trail, Bear Creek Canyon, and Colorado Springs; October 8, from Glen Eyrie, by way of Blair Athol, Pike View, Pope Ranch, and Palmer Park; October 9, from Colorado Springs by way of Colorado Springs and Cripple Creek Railway to Clyde, thence by wagon to an altitude of about 10,000 feet, returning by same route to Colorado Springs; October 10, from Colorado Springs by way of the Colorado Midland Railroad to Woodland Park, thence by wagon to Manitou Park; October 11, by saddle from Manitou Park east to Palmer Lake, thence by wagon southeast by way of Husted to Woodland Ranch; October 12, in the Colorado pinery on the Arkansas and Platte divide; October 13, in the Colorado pinery, returning by way of Colorado Springs to Glen Eyrie.

Additional explorations were made on the 12th and 13th by Mr. Edmonston, under my instructions, in the vicinity of Palmer Lake.

During all but one of these trips I was accompanied by Mr. W. D. Edmonston, head ranger of the Pikes Peak Forest Reserve, who was designated by Forest Supervisor Clarke as the proper official to receive instructions in the identification of the infested trees to be felled and barked to kill the principal insect enemies. I was also accompanied on a number of the trips by General Palmer's foreman, who received similar instructions. Supervisor Clarke accompanied us on two trips, General Palmer on three, and Forest Assistant Clement on two.

SUMMARY OF RESULTS, CONCLUSIONS AND RECOMMENDATIONS.

(1) The depredations by the Black Hills beetle (*Dendroctonus ponderosæ* Hopk.) within the area examined are by no means as extensive as we were led to believe from the reports and correspondence.

(2) The principal areas of recent damage by this beetle in the reserve and on private lands are in the vicinity of Cascade and Palmer Lake; but evidence of old and new work was observed to be more or less frequent in all sections visited.

(3) The evidence found on old, dead, standing, and felled trees of the work of the Black Hills beetle on pine, the spruce-destroying beetle (*Dendroctonus piceaperda* Hopk.) on Engelmann spruce, and the Douglas spruce Dendroctonus (*D. pseudotsugæ* Hopk. MSS.) on Douglas spruce indicate that all of these species have been present and destructive to living timber in this region for at least fifty years. The number and distribution of such old beetle-marked trees indicate that very extensive depredations have been wrought by them in the Pikes Peak region within the past century; and present conditions also indicate that a large per cent of the vast destruction of timber, heretofore attributed to fire, was primarily due to the work of these insects.

(4) The three species of bark beetles above mentioned are without doubt the most important insect enemies of conifer forests in the central Rocky Mountain region; hence they are a constant menace to the remaining living timber in and around the reserves of central Colorado.

While at present the spruce-destroying beetle appears to be rare, and the Douglas spruce and Black Hills beetles are not common enough to cause extensive depredations, it is plain, from what is known of the destructive powers of these insects, that if neglected and if specially favorable conditions for their multiplication should prevail for two or more years in succession they could easily destroy all of the timber of commercial size and a large per cent of the reproduction.

THE BLACK HILLS BEETLE.

The Black Hills beetle (*D. ponderosæ*) is at present the most common and destructive enemy of the living pine timber in and around the Pikes Peak Reserve; therefore it should receive primary consideration.

The best success in any efforts by forest officials or private owners of forests to control this beetle will depend on a sufficient knowledge of the species, its habits, life history, and the influences which are favorable or unfavorable for its increase and destructive invasions.

Insufficient knowledge on these points results in the confusion of the primary and secondary enemies of the tree, unnecessary expenditure of time and money, by felling and barking trees at the wrong time of the year, or after the broods of the primary enemy have emerged, the felling of living trees which would have recovered, and the unnecessary destruction of beneficial insects and insect diseases by burning the bark.

The following description of distinctive characters of the beetle, its work, habits, life history, etc., is based on the results of our studies of the species in the field and laboratory, brought up to date, regardless of what has been previously published or given out in correspondence.

CHARACTERS OF THE BEETLE (FIG. 1).

The distinctive characters of the Black Hills beetle are its length, which is from one-sixth to one-fourth of an inch; its stout form, with broad head and prothorax; its black color, and the rounded or convex rear end of the body (declivity of the elytra), which is without conspicuous long hairs. The allied species, which may be mistaken for it, are distinguished as follows: The large red turpentine beetle (*Dendroctonus valens* Lec.) is much larger, is dark reddish in color, never black, and forms large masses of pitch at or toward the base of living and dying pine trees and stumps. The Colorado Dendroctonus (*D. approximatus* Dietz) is black, with broad head, but the body is more elongate, the front of the head is grooved, and the declivity of the elytra has long, stiff hairs; it lives in the bark of pine, but makes a winding, sometimes branched, gallery. The spruce-destroying beetle (*Dendroctonus piceaperda* Hopk.) is reddish brown to black, but with much narrower head, with long hairs on the declivity of the elytra, and is always found in spruce. The Douglas spruce beetle (*Dendroctonus pseudotsugæ* n. sp.) is dark red or brown, and always breeds in Douglas spruce and western larch. The species which most closely resembles the Black Hills beetle is the mountain-pine beetle (*Dendroctonus monticola* Hopk.), which is only distinguished in the adult stage by the smaller size, slightly less stout form, less distinctly roughened elytra, and more obscured rows of punctures on the sides of the elytra, the latter being the most important character for its distinction.

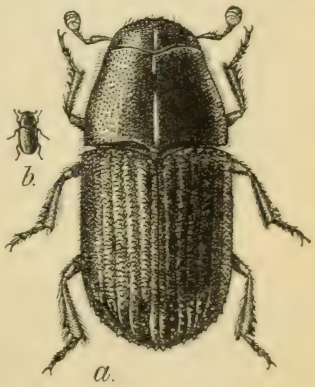

FIG. 1.—The Black Hills beetle: *a*, adult, enlarged; *b*, same, natural size. (Author's illustration.)

CHARACTERS OF THE GALLERY (FIGS. 2 AND 3 AND PL. I).

The primary gallery excavated in the bark by the Black Hills beetle is distinguished from that of any other species as yet known to live in the pine of the Black Hills or Colorado by the slight curve at the entrance end and the almost straight course with the grain through the inner layers of bark, and grooving the surface of the wood. There is only one pine-infesting species with which this form

of gallery can be confused, namely, the mountain pine beetle, which has not as yet been found in the same region. If it should occur, however, the galleries may be distinguished by the smaller size, more

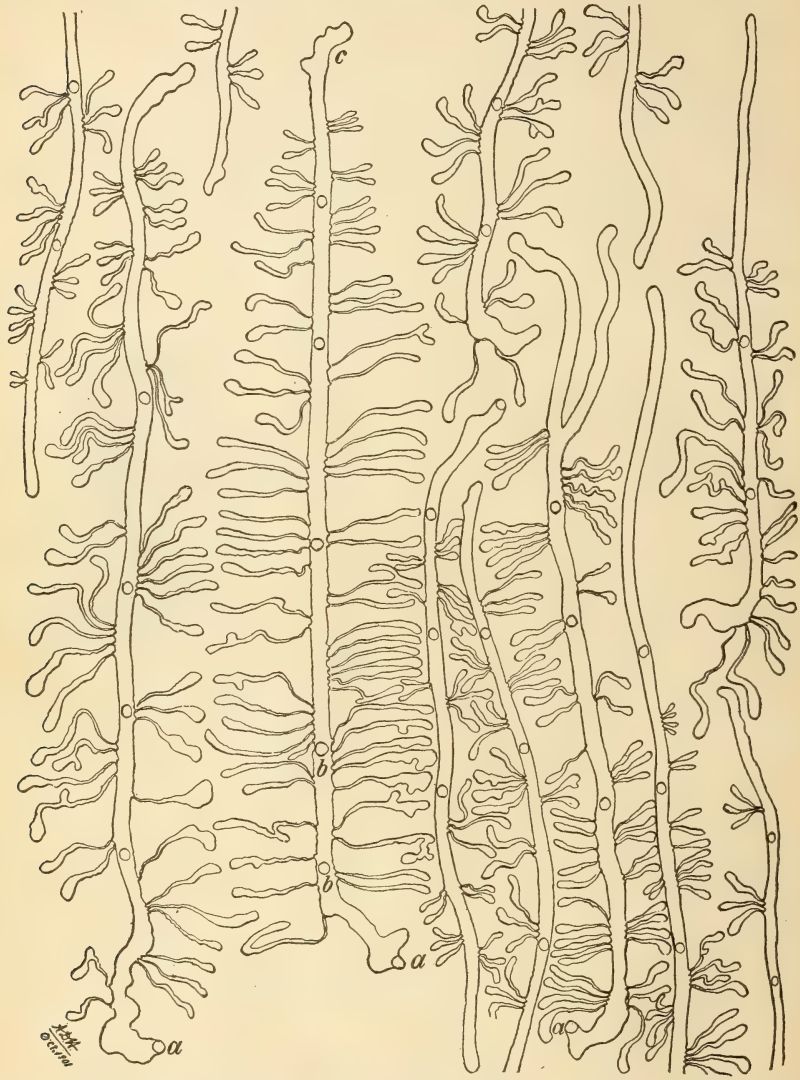

FIG. 2.—Work of the Black Hills beetle (*Dendroctonus ponderosæ* Hopk.). Primary galleries and larval mines in inner surface of living bark: *a*, entrance and basal chamber; *b*, ventilating holes in roof of gallery; *c*, termination. The larval mines radiate from the primary galleries. About one-half natural size. (Author's illustration.)

crooked and slightly winding course, and by the fact that they are more commonly met with in the silver pine, limber pine, and lodgepole pine. Whenever the Black Hills species is found in spruce the

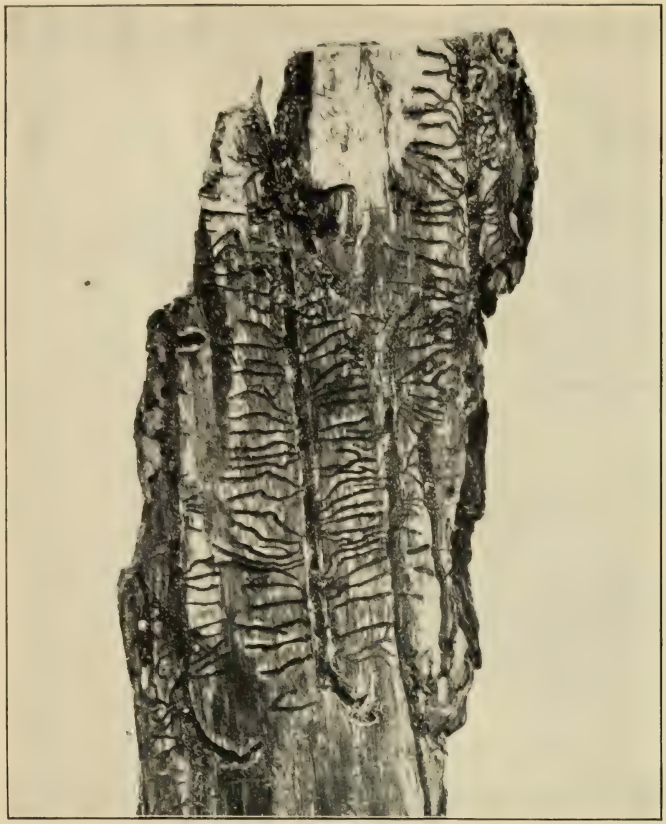

FIG. 1.—PRIMARY GALLERIES AND LARVAL MINES IN INNER BARK. ABOUT ONE-THIRD NATURAL SIZE. (AUTHOR'S ILLUSTRATION.)

FIG. 2.—MARKS OF PRIMARY GALLERIES ON SURFACE OF SCORING CHIP. ABOUT ONE-THIRD NATURAL SIZE. (AUTHOR'S ILLUSTRATION.)

WORK OF THE BLACK HILLS BEETLE.

gallery is distinguished from that of the spruce-destroying beetle by its slender form and more evenly distributed side or brood mines.

CHARACTERS OF THE INFESTED TREES (FIG. 4 AND PL. II).

Trees attacked by the Black Hills beetle between July and October will be indicated by the presence of pitch tubes, or sawdust borings, and upon removal of the bark the young broods will be found mining through the inner living layers, or the bark will be entirely killed on the main trunk; but the foliage will remain green, or will be but faintly faded until May and June of the following year, when the leaves on the lower branches will turn yellow and die. This condition will rapidly extend to the topmost leaves, so that by the time the broods of maturing beetles are ready to emerge the foliage is yellowish red to light reddish brown in color. This is the stage of death called "sorrel tops." Later in the summer and during the following winter, after all living examples of the beetle have emerged, the foliage is dark reddish brown, called "red tops." This condition prevails during the second summer after attack; but by the third summer all, or nearly all, of the leaves have fallen, which gives the tops of the dead trees a blackish appearance, called "black tops."

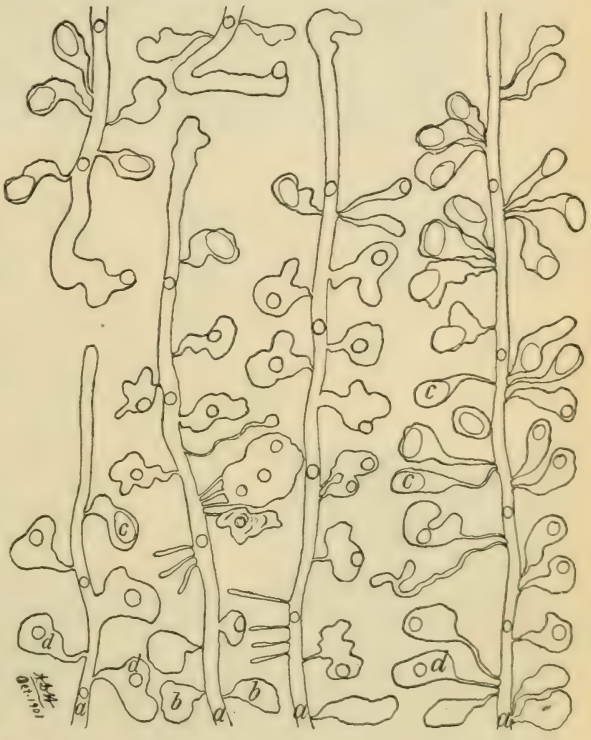

FIG. 3.—Work of the Black Hills beetle, in inner bark of dead tree: *a*, primary galleries; *b*, larval mines; *c*, pupal chambers; *d*, exit holes. Reduced about one-half. (Author's illustration.)

Beginning with freshly attacked trees during the first summer, they are distinguished by the exudation of fresh whitish or reddish pitch forming small masses or tubes on the bark of the main trunk or by the presence of fresh reddish sawdust-like borings lodged in the loose bark and around the base of the tree.

Trees infested with partially to fully developed broods from the latter part of August to the first of November, and during the period of inactivity, are distinguished by numerous pitch tubes over and entirely around the middle portion of the trunk and extending more or less toward the base and top. The age of the pitch tubes is indicated by their relatively moist or dry condition. A successful or vital infestation will be shown by the large number of pitch tubes surrounding the entire trunk, and also by their reddish color and general appearance. An unsuccessful attack—from which the tree will recover—is indicated after the first of November by a small number of smooth whitish pitch masses scattered about over the trunk, confined to or toward the base; their absence on the middle to upper portion of the trunk or, if present there, their failure to completely surround it.

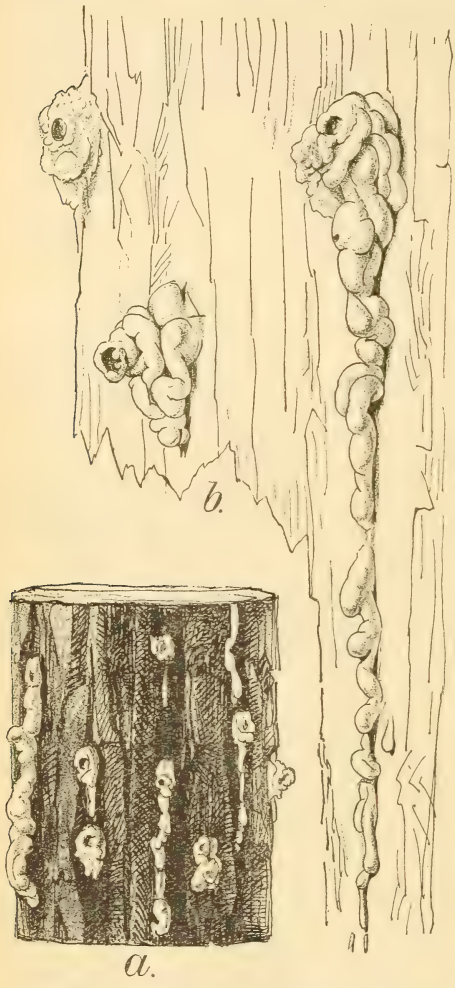

FIG. 4.—Work of the Black Hills beetle: *a*, pitch tubes on surface of bark, much reduced; *b*, same, two-thirds natural size. (Author's illustration.)

Positive evidence as to whether or not a green-topped, pitch-marked tree is infested by living broods is determined only by cutting into the bark at different places, 4 to 8 feet from the base. This test should be made during the inactive period, when trees are being marked for cutting.

Soon after activity begins in the spring, infested trees are distinguished by a pale appearance of the foliage, followed by a yellow or reddish brown color, as if killed by fire.

Dead trees which have been killed by the Black Hills beetle but are no longer infested by living broods are distinguished during the summer, fall, and winter by the old dry pitch tubes on the bark and the dark reddish brown or "black-topped" condition. The only

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FIG. 1.—MARKS OF PRIMARY GALLERIES ON SURFACE OF WOOD WHEN BARK IS REMOVED. (AUTHOR'S ILLUSTRATION.)

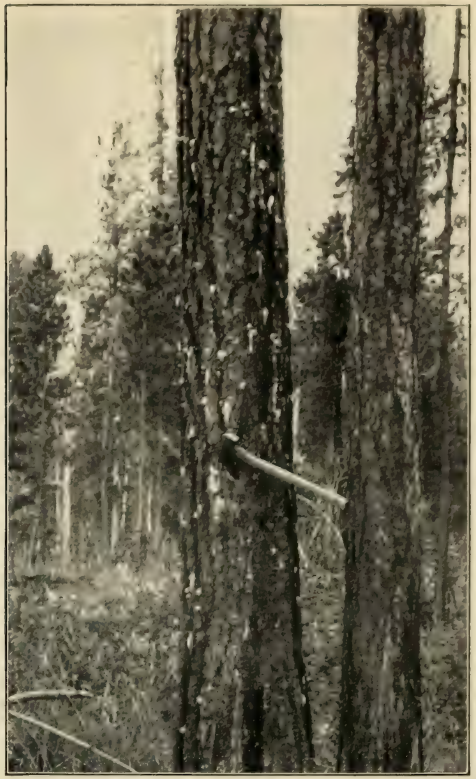

FIG. 2.—FRESHLY ATTACKED TREE, SHOWING PITCH TUBES. ADJOINING TREE NOT ATTACKED. (AUTHOR'S ILLUSTRATION.)

WORK OF THE BLACK HILLS BEETLE.

exception to this is when the top portion of the tree or one side of the trunk is killed the first year and a brood develops in the remaining living bark the next year. This sometimes occurs, but is never common enough to require special notice. Its occasional occurrence, however, explains why broods of the beetle are sometimes found in trees which appear to have been dead for two or three years.

LIFE HISTORY.

The insect passes the winter, or inactive period, in all stages—as larvæ, pupæ, and adults—beneath the bark of trees attacked by the parent beetles during the previous summer and fall. Activity begins in the spring as soon as sufficient warm weather prevails, when the broods continue to develop and mature, but remain in the bark until about the middle of July (Black Hills, latitude 44°, altitude 7,000 feet), probably later northward and at higher altitudes, and earlier southward and at lower altitudes. When the adults (fig. 1) begin to emerge from the bark of the trees in which they had developed from eggs deposited the previous year, they usually fly in swarms, and attack the living trees, in which they excavate galleries through the inner layer of bark and groove the surface of the wood. Along the sides of these primary galleries excavated by the beetle, eggs are deposited for the next generation, which, as before, hatch into grubs or larvæ (fig. 5), which mine at right angles to the primary galleries through the inner bark, on which they feed. This feeding and growing stage continues during the first summer, some of the individuals completing their development before fall, so that all stages, including the pupæ (fig. 6), may be found during the fall in the trees attacked in July. These with the younger broods remain dormant during the winter and complete their development the following spring in time to emerge in their regular course during the following summer.

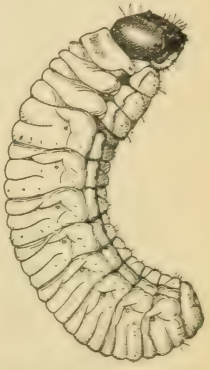

FIG. 5.—Larva of the Black Hills beetle. (Author's illustration.)

FIG. 6.—Pupa of the Black Hills beetle. (Author's illustration.)

The period of flight of the beetles and of their attack on living trees, as well as the egg-depositing period, is about seventy-five days, beginning about the middle of July and ending about the first of October. The exact time of the beginning and ending of this period in a given locality depends upon the latitude, altitude, and local conditions. The normal period of development of a brood from the time the living tree is attacked and the eggs deposited until the adults emerge from the

dying or dead trees is about three hundred and forty days. The period of activity—the feeding, growing, and maturing stages—of all broods of a single generation during the first summer is about ninety days—July 15 to October 15—and about one hundred and fifty days from the time activity begins the following spring—early in May—until the last individual has developed and emerged—early in October. Thus there is a total active period of about two hundred and forty days. The period of inactivity—from about October 15 to early in May—is about one hundred and ninety-five days, making the total period of infestation of all broods of a single generation about four hundred and thirty-five days. This, of course, provides for an overlapping of the last broods of one generation and the first broods of the next, during July, August, and September.

NATURAL AND ARTIFICIAL INFLUENCES.

DROUGHT AND COLD.

It has been a common belief that the dying of the timber is caused by drought, but it is now clearly demonstrated that wherever the Black Hills beetle is abundant it kills the healthiest trees under all conditions of dry and wet seasons, moist or dry soils, north or south slopes, ridges, etc. It has also been demonstrated that it can withstand a temperature of 30° to 40° F., or more, below zero.

LIGHTNING.

It has been found that trees struck by lightning, or at least those struck in summer, are usually attacked by this beetle, and that such trees serve to perpetuate the species at times when it does not occur in sufficient numbers to kill trees on its own account. Such trees also serve to support the natural enemies of the beetle, including insects, diseases, and birds.

STORMS.

Storm-felled living trees also serve as emergency breeding places, and if the storm occurs at the proper time in the year to make the conditions especially attractive to the beetles when they are flying, they may be attracted for long distances. This concentration of scattering forces breeding in felled timber may form the nucleus for a destructive invasion. This has been demonstrated from time to time in Europe, where even secondary enemies of the genus Tomicus have been thus enabled to multiply in such great numbers as to attack and kill living forests.

FIRE.

Our observations so far have failed to reveal much evidence that this species will breed in trees injured or killed by fire in sufficient

numbers to materially aid their increase. Indeed, newly fire-scorched trees observed near a sawmill in the Manitou Park section showed no trace of the presence or work of this beetle, although the trees were being attacked by several species of secondary enemies, including the true turpentine beetle (*Dendroctonus valens* Lec.). On the other hand, an extensive forest fire may contribute to the destruction of the Black Hills beetle by burning the dead bark from the living and dying infested trees, which may explain the evident sudden endings of old invasions.

COMMERCIAL CUTTING.

The cutting of living trees for commercial purposes has apparently little or no influence on the multiplication of the beetle. While it will breed in freshly cut logs from living trees, our experiments show that it prefers to attack standing timber. Then, again, any operations which involve the removal of the bark from the logs for ties, mining timbers, etc., will destroy any broods which may be therein. If cut into cord wood, the bark will soon become too dry for the insect to live in. Slabs from freshly cut logs may favor its development in small numbers, but usually the conditions in such material are not favorable. Neither do the green stumps, so far as we have observed, offer sufficiently attractive breeding places for this beetle to warrant the barking of such stumps. Nothing in the slash will offer favorable breeding places, except the tops of the main trunk, and this is seldom sufficient to warrant any special treatment.

SUMMER CUTTING IN PATCHES.

The cutting of living infested trees and of healthy trees in local commercial cuttings is objectionable from the fact that we have found that when a few living trees are felled in the midst of a forest where this beetle is present in numbers it will be attracted by the odor and will attack the surrounding standing timber. Therefore such local summer cuttings should be avoided.

TRAP TREES.

This is a method of combating bark beetles in which trees are girdled or felled to attract the insects to them, after which the broods are destroyed by stripping off the bark or burning the entire tree.

Trap-tree experiments were conducted by Mr. J. L. Webb, under the writer's instructions, in the Black Hills Reserve in 1902, in which trees were felled, hack girdled, girdled to the heartwood, belt girdled, and hacked and peeled at intervals of five or six days between June 2 and October 30. The result of this experiment showed conclusively that no method of preparing the trap trees was of sufficient

value in its attractive influence on the Black Hills beetle to warrant its adoption in efforts to control this insect. While many of the trap trees were attacked, the percentage and density of the infestation were no greater than in near-by or distant healthy trees. On the other hand, it was shown conclusively that the felled trap trees were especially attractive to one of the most important secondary enemies, namely, the Oregon Tomicus (*Tomicus oregoni* Eichh.).

NATURAL ENEMIES.

INSECTS.

While a number of insect enemies of the Black Hills beetle have been found during our investigations, they appear to have little effect when the timber is dying over large areas, but under normal conditions of scattering infested trees they seem to render valuable service in preventing the rapid multiplication of the destructive beetle.

BIRDS.

The work of woodpeckers is frequently seen on infested trees, but, like the beneficial insects, they do their greatest service, perhaps, in helping to preserve the normal balance in the struggle of the trees against insects and of the insects against their own enemies.

DISEASES OF INSECTS.

Evidence was frequently found of the destruction of part or all of the broods in an infested tree by fungous diseases, but to what extent this factor affects the decrease of the beetle has not been determined.

SECONDARY ENEMIES OF THE TREES, AND NEUTRAL INSECTS.

Insects which attack only weakened, dying, or dead trees, and those associated with a destructive or primary enemy are called secondary enemies. Insects which simply live under the bark or feed on fungi, dead wood, and bark are in no manner responsible for injury to the tree. Thus they are either neutral insects, scavengers, or guests.

There are so many of all of these classes of insects associated with the Black Hills beetle in trees killed by it that it would require too much space to discuss them in this connection; but it seems necessary to say that the greatest care should be taken to avoid confusing some of the species of secondary enemies with the primary one, and that when there is the slightest doubt specimens should be sent to this Bureau for identification.

METHODS OF CONTROL.

The results of our investigations to date suggest but slight changes in our recommendations in 1901 and 1902, published in Bulletin 32 (pp. 21, 22), as follows:

It appears that the pine-destroying beetle of the Black Hills, like its eastern relatives, depends on the trees killed by it for the augmentation of its numbers and the perpetuation of its power of killing more trees. Therefore it is only necessary that the attacking force be reduced to a point where it can no longer overcome the vital resistance of the trees on which it concentrates its attack in order to successfully defeat it.

The fact that the attacking force of the enemy is already weakened from natural agencies suggests that they can be reduced by artificial means below their power of killing more trees next season, and thus bring the trouble to an end. Therefore the following are suggested and recommended as probably the best methods of accomplishing this result:

(1) Determine the location and extent of areas in which trees were attacked during the summer and fall (of 1901) and the number of trees now infested with living broods of the pine-destroying beetle.

(2) Select those areas in which there are the largest number of infested trees and mark the same for cutting.

(3) Secure, by sale contracts or otherwise, the cutting of these trees and the removal of the bark from the infested parts of the main trunks and stumps prior to May 1 (1902). The drying of the removed infested bark and surface of the wood will effectually destroy the insects. In addition the logs so treated will be protected next spring and summer from the attack of wood-boring insects, and thus be almost or quite as valuable for all commercial purposes as if cut from living trees.

It is not necessary that all infested trees in the reserve or those of all other infested areas should be thus cut and barked, but it is important that a large percentage should be so treated in order to insure a sufficient reduction of the beetles to check their destructive ravages.

Experience has shown quite conclusively that the above recommendations are entirely practicable, and it has also been demonstrated that whenever the felled trees are accessible for lumber, ties, mining timbers, or cord wood it can usually be sold for more than the cost of cutting and barking.

APPLICATION OF THE METHOD IN THE BLACK HILLS.

There has been a continued effort to control this destructive beetle in the Black Hills Reserve since 1901, but the adoption of the necessary radical measures was prevented by certain regulations governing the management of the reserve, which required the advertising and sale of the old dead and dying timber, for which there was not a sufficient demand in the State of South Dakota; and since a special provision of the law prohibited the shipment of timber out of the State, it was practically impossible to accomplish anything of importance.

We are informed, however, that the evident benefit in certain sections resulting from cutting and barking the infested timber is such as to indicate that if more radical measures had been adopted under a more liberal policy of timber sales, and under a temporary amend-

ment of the laws relating to its shipment out of the State, the destructive beetle could have been brought under complete control and millions of feet of valuable timber saved without cost to the Government.

APPLICATION OF THE METHOD IN COLORADO.

Pursuant to our recommendations, a large number of trees were felled during the past summer (1905) on private lands in and around Palmer Lake, Colorado, where between 500 and 1,000 trees had been killed within recent years over a comparatively small area. Observations by the writer in October, and explorations by Ranger Edmonston in that vicinity, indicated a very slight new infestation this year. It is evident, therefore, that the efforts of the town board and of the citizens in cutting and barking the infested trees has had the desired effect in partially, if not completely, checking the destructive work of the beetle. If this good work is supplemented with a like effort on the part of forest officials during the coming winter, there is every reason to believe that the trouble in this vicinity will be brought under complete control, and that with a little well-directed effort each succeeding year it can be kept within normal bounds.

The same method was adopted by General Palmer and others,under the direction of Professor Bruner, in the vicinity of Colorado Springs and the Colorado pinery on the Platte and Arkansas Divide. The operation of barking and felling the affected dead and dying trees extended over an area of probably 150,000 acres, and between 600 and 800 trees were felled and barked, and the bark burned with the tops.

A thorough examination of this area by the writer indicates quite conclusively that the forces of the enemy have thus been sufficiently weakened to make their complete subjugation a comparatively easy matter, especially if the principal areas of present infestation in the reserve receive the proper treatment between now and the first of May.

It is evident to the writer that in both localities considerable unnecessary expense was involved in the cutting of old dead trees from which the enemy may have escaped and of those which might have recovered, as well as in burning the bark and tops, peeling the stumps, etc.; but it is plain that the losses from such unnecessary expenditures are of little consequence as compared with the great good accomplished.

FURTHER RECOMMENDATIONS RELATING TO THE CONTROL OF THE BEETLE.

(1) Explorations should be made, preferably during August, September, and October, to locate the principal areas of new infestation.

(2) Mark for cutting all clumps or patches of infested trees and some of the more accessible scattering ones in the worst-infested sections.

(3) The best time to fell and bark infested trees is between the middle of October and the first of May.

(4) If there is no demand for the timber, and more can be accomplished by piling the trunks and tops and burning them, or sufficiently scorching the bark to kill the insects, this method may be followed; but barking the infested portion of the trunks, without burning the bark or tops, is preferable, since it will avoid the destruction of many beneficial insects, and the exposed broods of the destructive beetle furnish food for birds.

(5) In some localities, and under certain conditions, it may be advisable to burn the tops, but if this is done to kill the insects it should be delayed until after the first of May and completed before the middle of June.

(6) If for any reason the work of felling and barking the trees can not be undertaken or completed before the first of May, it may be done during May and June. The necessity for burning the bark and tops at such time will depend upon local conditions and requirements.

(7) Summer operations should be avoided. There is nothing to be gained in felling freshly attacked trees which can just as well be cut in the fall and winter. In addition, there is danger of the freshly felled and barked trees exerting an attractive influence on the swarms of beetles which will cause them to attack the surrounding living timber. Then, again, any burning operations during the summer involves the danger of starting forest fires.

(8) If it is especially desirable, on account of timber sale and logging contracts, to cut the old dead as well as the newly infested living trees during the active period of the insect—May to October—a thorough exploration should be made by a forest entomologist or a trained forester, who should be responsible for the marking of the infested living trees. It is also important that all cutting of infested timber be concentrated in the worst affected localities.

(9) The burning of summer slash and the barking of stumps of trees which are healthy when felled is not necessary as a preventive measure against the Black Hills beetle, and the necessity for doing so against any other insect depends entirely on the species involved and local conditions.

(10) The result of experiments and observations indicate that the trap-tree method can not be successfully adopted for this insect.

(11) If a large amount of pine timber is blown down at any time, but especially in June and July, it should be carefully watched during the first year or two to determine whether or not it is attacked by the Black Hills beetle, and, if so, the bark should be removed during the fall after the attack is made.

NOTE.

The statements in this bulletin under the headings of "Life History," "Natural and Artificial Influences," and "Methods of Control" relate to the Black Hills beetle alone and are not applicable to any other species of barkbeetle.

INDEX.

	Page.
Adult, character	11
Attack, influences aiding or inducing	16
Birds as natural enemies	18
Cold, as affecting infestation	16
Colorado Dendroctonus, distinguishing characters	11
Control, in Black Hills	19–20
in Colorado	20
methods	19, 21
Damage, extent	5
Dendroctonus approximatus, distinguishing characters	11
Colorado. See *Dendroctonus approximatus.*	
Douglas spruce. See *Dendroctonus pseudotsugæ.*	
monticola, distinguishing characters	11
piceaperda, distinguishing characters	11
work in dead Engelmann spruce	10
ponderosæ—subject of this bulletin.	
pseudotsugæ, distinguishing characters	11
in western larch	11
work in dead Douglas spruce	10
rufipennis, wrong determination	6
terebrans, wrong determination	6
valens, attacking fire-scorched trees	17
distinguishing characters	11
Destructiveness	5
Development, time required	16
Diseases	18
Distribution	5
Douglas spruce, attacked by *Dendroctonus pseudotsugæ*	10
Dendroctonus. See *Dendroctonus pseudotsugæ.*	
Drought, as affecting infestation	16
Eggs, time of depositing	15
Enemies, insect	18
Fire, as affecting infestation	16
Food plants	5
Fungous diseases	18
Gallery, character	11
Infested trees, indications of attack	13
Larch, western, attack of *Dendroctonus pseudotsugæ*	11
Larvæ, diseases	18
habits	15
Life history	15

Page.
Lightning, as cause of infestation 16
Mountain-pine beetle. See *Dendroctonus monticola.*
Natural enemies 18
Neutral insects 18
Oregon Tomicus. See *Tomicus oregoni.*
Parasitic enemies 18
Picea canadensis, attack of *Dendroctonus ponderosæ* 5
engelmanni, attack of *Dendroctonus ponderosæ* 5
Pine, bull. See *Pinus ponderosa.*
limber. See *Pinus flexilis.*
western yellow. See *Pinus ponderosa.*
Pinus flexilis, attack of *Dendroctonus ponderosæ* 5
ponderosa, attack of *Dendroctonus ponderosæ* 5
Pitch tubes 13
Predaceous enemies 18
Remedial measures. *See* Control.
Secondary enemies of trees 18
Spruce, Douglas, attack of *Dendroctonus pseudotsugæ* 10
Engelmann. See *Picea engelmanni.*
attack of *Dendroctonus piceaperda* 10
See also *Picea engelmanni.*
white. See *Picea canadensis.*
Spruce-destroying beetle. See *Dendroctonus piceaperda.*
Storm-felled trees, inducing infestation 16
Temperature, as affecting infestation 16
Tomicus oregoni, attack on trap trees 18
Oregon. See *Tomicus oregoni.*
Trap trees 7, 17
Turpentine beetle, large red. See *Dendroctonus valens.*

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